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4. QUALITY ASSURANCE/QUALITY CONTROL AND DATA MANAGEMENT

During the course of the investigation activities performed at the Site during the period from January 1996 through November 1997, a significant amount of data was obtained. Likewise, historical environmental investigations conducted throughout the Airport/Klondike Area have resulted in a significant amount of additional data. These data included analytical data on soil, groundwater, soil vapor, concrete chip, surface water, and sediment samples, geologic boring logs, monitoring well construction logs, field activities documentation, sample tracking documentation, and other documentation associated with the sample collection and analyses. During the course of the field investigation activities, the need to maintain accurate and complete documentation of each phase of the investigation was a paramount concern. Included in this section is a description of the activities undertaken to document, manage, validate, verify, organize, and present the data compiled during the investigation activities performed to date.

This section has been organized to present those activities performed by field personnel with a consistent, appropriate set of standard operating procedures (SOPs) to provide guidance on conducting field operations. By conducting field operations in a consistent manner, the analytical data generated are more comparable between various phases of the investigation. Next is presented a discussion of activities conducted to document the record of investigation activities performed in the field and discuss the quality assurance/quality control (QA/QC) tasks performed in the field. These discussions are followed by a description of the activities undertaken by personnel in the office to ensure the necessary data had been accumulated, that the data had been properly managed, tracked, validated, verified, entered into the database repository, and at the conclusion of the investigation, filed for future use.

In general, as the maturity of the environmental investigations has increased, so has the level of QA/QC. Some of the QA/QC discussion presented in this section is relevant only to later portions of the investigation. In most cases, however, these processes have been applicable to the full investigation, including many of the historical investigations.

4.1 Standard Operating Procedures

4.1.1 General

Prior to conducting the Airport/Klondike investigation, SOPs had been developed for several of the most common procedures associated with the monitoring, sampling, and analysis of various media for environmental investigations. Development of these SOPs has taken into account the need for precision, accuracy, completeness, representativeness, and comparability of data.

Although it is understood that there are limits on data accuracy and precision that are inherent in the collection and analysis of samples and in the operation of measuring devices, adherence to standard procedures will increase consistency and the level of confidence with which the data collected is evaluated. Data collected under standard procedures can also be used more reliably in comparing results over time on a given project or from other projects or to published information.

Data evaluation is also dependent upon the representativeness of the samples or measurements collected and the completeness of information associated with collection of the data. Collection and measurement techniques identified in the SOPs have been designed to take these factors into account, thus increasing the level of confidence that can be placed in the data.

Understanding that adherence to standard operating procedures is imperative for the successful completion of any project, there will be instances where exceptions to the SOPs must be made to obtain reliable data. When exceptions are made, documentation of both the situation requiring deviation and the actual deviation in procedure was recorded in the field documentation.

4.1.2 Development of Standard Operating Procedures

Each SOP was developed by personnel experienced in the performance of the specific activity. At least two senior-level people, one an officer of the company, reviewed the SOP to ensure that the identified procedures satisfy the stated objectives and that the prescribed procedures are technically correct, appropriately applied, and in conformance with applicable regulatory criteria and standard practices. These individuals signified their approval by signing and dating the SOP.

Standard Operating Procedures for the following activities have been included in Appendix of the "Voluntary Corrective Action Program Work Plan, Pratt & Whitney, Connecticut Facilities" (VCAP Work Plan):

- Soil Sampling
- Surface Water and Sediment Sampling
- Geoprobe® Probing and Sampling
- Geoprobe® Screen-Point® Groundwater Sample Collection
- Hollow Stem Auger Soil Borings
- Geologic Logging of Unconsolidated Sedimentary Materials

- Monitoring Well Installation
- Liquid Sample Collection and Field Analysis
- Soil Vapor Surveying
- Quality Assurance/quality Control Measures for Field Activities
- Operation of the Portable Gas Chromatograph
- Sample Management Associated With the LEA Analytical Laboratory

4.2 Field Quality Assurance Procedures

4.2.1 Use and Maintenance of Field Equipment and Instrumentation

All field equipment and instruments were operated and maintained in a manner that is consistent with the manufacturer's recommended practices. Any deviations from standard use of the equipment or required repairs or adaptations made in the field were noted in the Field Record and/or field logbook. Operation and maintenance manuals for all equipment were kept in a single location that was known and accessible to all personnel that would be likely to use the equipment.

Field personnel either returned equipment in a condition that permitted its optimal use on the following day of field operations, or notified the appropriate personnel so that repairs/replacements could be arranged in an expedient fashion. The use of expendable equipment was recorded and reported to authorized personnel so replacements could be ordered in a timely manner and an adequate supply was always available.

Prior to starting a particular field investigation, the field services manager or designated personnel ensured that adequate supplies and equipment were available for project completion. It was the responsibility of field personnel to inform the field services manager, or other authorized personnel, that supplies were depleted and that re-ordering was necessary.

4.2.2 Calibration Procedures and Frequency

Instruments and equipment were calibrated with sufficient frequency, and in such a manner, that accuracy and reproducibility of results were consistent with the appropriate manufacturer's specifications or project-specific requirements. Calibration was performed at intervals recommended by the manufacturer or more frequently, as conditions dictated. Field instruments that required calibration included: pH, specific conductance, and dissolved oxygen meters; turbidity meter; organic vapor analyzers; explosive gas/oxygen meters; velocity meters; and portable gas chromatographs.

Documentation and results of instrument calibration was recorded on the Instrument Calibration Check Form. This form, one of the field forms that was completed for each day the equipment was used, was used to record calibration data or each instrument at the beginning of each day of use and, where appropriate, at the end of each day of use (except as noted in the manufacturer's instructions). Documentation of calibration that was performed for instruments such as pH meters, dissolved oxygen meters, organic vapor analyzers, and portable gas chromatographs was recorded on field documentation forms, analytical records, or other appropriate daily record of activities. Instrument-specific calibration requirements were included in the appropriate SOPs. Calibration of health and safety equipment was included in the Health and Safety Plan.

4.3 Sample Tracking, Collection, and Preservation

Field sample tracking activities focused on the assignment and tracking of information relevant to field samples collected during the investigation activities. This information included sample identifiers, sample locations, chain-of-custody information, and sample characteristics. Specific sample tracking procedures employed during the investigation activities were the same as those detailed in the VCAP Work Plan.

Samples collected during the investigations were designated using the procedures discussed below. In general, sample identification information included the following:

- Site location;
- Date and Time;
- Sample matrix;
- Sample type;
- Sample point number; and,
- Sample depth interval (where applicable).

Field sample tracking activities focused on the timely and accurate tracking of sample identifiers, chain of custody information, sample station identifiers, sample characteristics, sample locations and milestone dates. This information was transmitted from field to office personnel through the daily field summary sheets and other project information tracking forms. Daily field summary sheets were completed by each field team leader. The daily field summary sheet detailed the daily activities conducted by the staff and contractors, hours logged by staff and contractors, problems encountered, general field observations, and samples submitted for analyses. Field summary sheets and project information tracking forms were submitted to the field activities coordinator at the end of each working day or as soon thereafter as possible. The summary sheets and forms, in turn, were placed in the central file.

Field Team Leaders completed, on a daily basis, a daily log sheet, which at a minimum detailed the people working in a given area, the hours worked, the tasks performed, the number and matrix of samples collected, and the number and matrix of samples shipped for analysis. The daily log sheets were submitted to the field activities coordinator.

Field sample tracking included the following tasks:

- Assignment of sample identification numbers and other sample identifiers to new samples to be taken, and entry to a tracking system;
- Production of sample bottle labels from the tracking system;
- Completion of Chain-of-Custody forms, and entry of this information to the tracking system;
- Entry of additional tracking dates to the tracking system;
- Quality assurance checking of the sample tracking information, and processing of change requests; and,
- Production of tracking reports and summary sheets, with distribution to appropriate project staff.

A computer-based sample-tracking system, based on a dBase® database computer program, was used for sample tracking.

4.3.1 Field Sample Collection Procedures

During the investigation activities conducted from approximately January 1996 through November 1997 all samples of the various environmental media at the Site were collected in accordance with the Standard Operating Procedures provided in the VCAP Work Plan.

4.3.2 Sample Labeling and Custody

Prior to sample collection, project-specific sample numbers were obtained, and labels completed with all required information, as noted in the sample collection SOPs. Each sample was labeled using waterproof ink on a computer-generated label, and sealed immediately after collection. At a minimum, each sample label had the following information:

- project number;

- date;
- sample number;
- time of sample collection; and,
- any preservatives used.

In order to ensure accurate identification of all sample containers, sample labels and tags needed to remain firmly affixed to the sample container. The sampler were responsible to ensure that the sample container was dry enough for the label to remain securely attached, or use a suitable transparent adhesive tape when the adhesive labels were not applicable or there was any question as to whether the gummed label would be secure.

All sampling information was recorded on the field sampling records. Written chain-of-custody procedures were followed whenever samples are collected, transferred, stored, analyzed, or destroyed. The objective of these procedures was to create an accurate written record that could be used to trace the possession and handling of the samples from its collection through analysis. A sample was determined to be in someone's "custody" under any of the following conditions:

- it was in one's actual possession;
- it was in one's view, after being in one's physical possession;
- it was placed and kept in a locked location after being in one's physical possession; or
- it was kept in a secured area that was restricted to authorized personnel only.

Each time sample custody changed hands, the chain-of-custody form was updated to indicate that change. All efforts were made to limit the number of people involved in the collection and handling of samples.

4.3.3 Field Documentation

Field logbooks or notebooks were used to record general field data collection activities or pertinent field observation or occurrences. Field logbooks or notebooks consisted of loose-leaf field-documentation forms completed daily by field crews and assembled in binders for preservation and reference. Entries were made in waterproof ink and each page was consecutively numbered for each sampling day. Each daily entry included the following information:

- name of person recording information;
- names of all field personnel;
- project name and number;

- date;
- start and end times;
- weather conditions;
- equipment used;
- samples collected;
- field parameters measured; and,
- equipment calibration performed.

Other information that was recorded in the field logbook included the level of personal protective equipment used, difficulties, accidents, incidents, equipment problems or malfunctions, or deviations from the work plan.

Any corrections made in the field logbook were crossed out, not erased, and initialed by the person making the correction. Each page of the logbook was signed by the person responsible for recording information on that day. All lines on a page, and all pages, were used.

4.3.4 Field Sampling Quality Assurance

Several QA samples were collected to confirm the reliability and validity of the field data gathered during the course of the investigations. Field duplicate samples were used to provide a measurement of the consistency of samples from the same sampling station and an estimate of variance and bias. Trip and equipment blanks were used to provide a measurement of cross-contamination sources and decontamination efficiency, respectively. Quality assurance procedures for field measurements were addressed through various SOPs and field protocols.

4.3.4.1 Field Duplicate Samples

During the Site investigation, an attempt was made to select one duplicate sample per 20 samples submitted for analysis at either the LEA Analytical Laboratory or at the off-site analytical laboratory. Soil samples were collected from soil borings advanced with the Geoprobe® during the majority of the focused soil sampling investigations. In many cases, the volume of sample required for the analysis of a field duplicate sample pair at the off-site analytical laboratory exceeded the volume of soil recovered from each 2-foot sampling interval and no duplicate sample for the off-site analytical laboratory could be collected. However, due to relatively low volume required, adequate soil volume was typically recovered to collect a field duplicate sample for analysis at the LEA Analytical Laboratory.

A summary listing of duplicate soil samples analyzed during the Site investigations is presented as Table 4-1. Table 4-1 summarizes the location identifier at which the duplicate sample pair was collected, the unique sample identification numbers for the duplicate sample pair, the sample date, and the depth interval from which the duplicate sample pair was collected. Table 4-2 presents a list of the analytical data by individual constituent for which each duplicate soil sample was analyzed and the relative percent difference (RPD) for each compound detected in the duplicate sample pair.

As noted in Section 3, groundwater samples were collected from onsite groundwater monitoring wells during events conducted since approximately 1990. In addition, groundwater was also collected from selected soil boring locations using a Geoprobe® Screen-Point® ground water sampling system. In contrast to the focused soil sampling activities, adequate groundwater sample volume was available to collect and analyze field duplicate groundwater sample pairs at an off-site analytical laboratory. Field duplicate groundwater samples were collected from randomly selected groundwater monitoring wells during each of the two sampling events. A summary listing of the field duplicate groundwater samples analyzed by an off-site analytical laboratory during the Site investigations is presented as Table 4-3. Table 4-3 is similar in format to Table 4-1 and summarizes the location identifier at which the field duplicate sample pair was collected, the unique sample identification numbers for the duplicate sample pair, the sample date, and the screened interval for the groundwater monitoring well from which the field duplicate sample pair was collected. Table 4-4 presents a list of the analytical data by individual constituent for which each duplicate groundwater sample pair was analyzed and the RPD for each compound detected in the duplicate sample pair.

A review of the analytical data for field duplicate samples analyzed by both the off-site analytical laboratories and the LEA Analytical Laboratory indicated that the relative percent difference between the data were generally within acceptable levels.

4.3.4.2 Blank Samples

Two types of blank samples, trip and equipment, were utilized during the investigation activities at the Site. A summary of all quality assurance blank samples analyzed during the Site investigations is provided as Table 4-5. A summary listing of constituents detected in each of the blank samples is provided as Table 4-6.

Trip Blank Samples: Trip blanks were collected each day for which samples were collected for analysis for the presence of volatile organic compounds (VOCs). Separate trip blanks were collected for each sample cooler used to transport samples collected for VOC analyses. Additionally, separate trip blanks were always collected for the LEA Analytical Laboratory and for the off-site analytical laboratory. Trip blanks were analyzed at an approximate rate of one sample per 20 samples submitted for VOC analysis. For example, if over a two day period a total of 54 soil samples were collected and submitted to the LEA Analytical Laboratory for analysis and 19 of these soil samples were selected for off-site analysis at Quanterra Environmental Services (QNT), a trip blank from each of the two days would be analyzed in LEA Analytical Laboratory and a trip blank for one of the sampling days would be analyzed at QNT.

Trip blank samples are identified in Tables 4-5 and 4-6 by a sample class of BKT. Volatile organic compounds were detected in 6 of the 204 trip blank samples analyzed by the LEA Analytical Laboratory. Volatile organic compounds were detected in 8 of the 108 trip blank samples submitted to the off-site analytical laboratories.

Equipment Blank Samples: Equipment blanks were obtained each day sampling activities were conducted at the Site and were collected for each environmental media sampled on that day. For example, if on a given day soil vapor, soil, and groundwater samples were collected, three separate equipment blanks were collected. Equipment blanks were submitted for analysis at the approximate rate of one per 20 samples of a given media submitted for analysis.

Equipment blank samples are identified in Tables 4-5 and 4-6 by sample class BKE. Volatile organic compounds were detected in 4 of the 205 equipment blank samples submitted to the LEA Analytical Laboratory for analysis. Volatile organic compounds were detected in 26 of the 79 equipment blank samples submitted to the off-site analytical laboratories for analysis. In addition to the VOCs detected, SVOCs, target metals and TPH were also detected in selected equipment blanks submitted to the off-site analytical laboratories.

4.3.4.3 Field Measurements

Field measurements, including those for pH, oxidation/reduction potential, dissolved oxygen, specific conductance, and temperature, are subject to QA considerations even in instances where sample collection may not have been performed. The primary QA objective for field measurements is to obtain reproducible measurements with a degree of accuracy consistent with the limitations of the analytical techniques and with the intended use of the data. Procedures for field measurements, equipment calibration (where appropriate), and equipment maintenance were discussed in the appropriate SOPs for each sample collection activity.

4.3.4.4 Sample Preservation

Appropriate sample preservation techniques assure that samples are maintained in a state in which analytes are not subjected to biological, chemical, or physical degradation, alteration, volatilization, or other physical loss, prior to the analytical process. Sample preservation techniques employed during the environmental investigations in the Airport/Klondike Area were consistent with the guidelines presented in *Test Methods for Evaluating Solid Waste SW-846*, Third Edition, December, 1986.

Sample preservation for soil samples destined for submission to off-site analytical laboratories consisted of maintaining the samples in sealed containers in coolers maintained at approximately 4° C. Soil samples destined for submission to the LEA Analytical Laboratory were placed into glass vials and submerged in pre-acidifed water to maintain a pH of approximately 2. These samples were also placed in coolers maintained at approximately 4° C. Specific containers and preservation techniques for soil samples are presented in Table 4-7.

Groundwater samples were preserved by various methods depending upon the specific analyte or group of analytes for which the sample was being analyzed. Specific containers and/or chemical preservation techniques for groundwater samples are presented in Table 4-7.

4.3.5 Chain-of-Custody

As noted above, soil vapor, soil, and groundwater were collected during investigation activities conducted at the Site. These samples were collected for the purpose of characterizing the nature and delineating the extent of contamination at the Site. Chain-of-custody procedures were used to maintain and document sample possession from collection through analysis. For this reason, the possession of samples was traceable from the time the samples were collected until they were analyzed. The following documents identified samples and document possession:

- Sample labels;
- Chain-of-Custody record forms; and,
- Field Documents, including field sampling records, boring logs, monitoring well construction logs, and groundwater sampling records.

The field sampler was responsible for the care and custody of the samples collected until they were hand delivered to the laboratories under chain-of-custody procedures.

4.3.6 Sample Shipping

Following sample collection, the filled sample containers were placed in coolers packed appropriately to avoid bottle breakage. Either freezer packs, or ice packed in zip-locked bags or plastic containers were placed in the coolers to keep the samples at a temperature not exceeding 4°C during transport to the laboratories.

Samples were hand-delivered and relinquished to the LEA Analytical Laboratory by LEA personnel at the end of each the sampling day. Samples submitted to off-site analytical laboratories were hand-delivered when appropriate, or packaged and shipped by next-day courier when the destination laboratory was not local.

Sample coolers destined for commercial shipping to the off-site analytical laboratories were packaged to avoid damage to sample containers, packed with a suitable volume of ice and sealed. Chain-of-custody forms were sealed inside the cooler and custody seals were used to assure sample integrity until receipt by the analytical laboratory.

4.3.7 Decontamination

Decontamination procedures are described in applicable SOPs presented in Appendix of the VCAP Work Plan. These procedures were designed to avoid cross-contamination between samples, the transport of contaminated material between on-site locations, and the transport of contaminated material from off-site locations to the Site, or from the Site to the off-site locations. As described in Section 4.3.4.2, equipment blank samples were collected to confirm the efficiency of decontamination procedures.

4.4 Data Quality Objectives

Data Quality Objectives (DQOs) are quantitative and qualitative statements specifying the quality of the environmental data required to support the decision-making process. Understanding the intended use of the data and analytical capability is an essential aspect of the development of the DQOs, since the DQOs define the uncertainty in the data that is acceptable for each specific sampling activity. This uncertainty includes both sampling error and instrumental measurement error. Although zero uncertainty would be the ideal, the variables associated with the collection and analysis process, in both the field and the laboratory, make this ideal unattainable. Understanding this, the objective of the quality assurance program is to keep the total uncertainty within an acceptable range that will not hinder the intended use of the data.

4.4.1 Data Quality Requirements

To ensure that the data collected met the DQOs, many types of field and laboratory QC samples were required. These samples included field blanks, trip blanks, laboratory method blanks, field and laboratory duplicates performance evaluation program samples, matrix spikes, and calibration and check standards. Analytical data from the Airport/Klondike Area investigation was evaluated for the parameters presented in the following sub-sections.

4.4.1.1 Accuracy and Precision

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter being analyzed. Sources of error that may contribute to poor accuracy include:

- laboratory error;
- sampling inconsistency;
- field and/or laboratory contamination;
- sample handling;
- matrix interference; and,
- preservation;

Sample preparation and analytical accuracy can be determined using known reference materials, or matrix spikes. Matrix spikes are added into the actual sample matrix or the laboratory's surrogate distilled and/or deionized water. By plotting the results of the matrix spike on control charts, a true picture of the process of sample analysis is obtained. This information, used in conjunction with matrix spike recoveries, aids in determining whether out-of-control conditions are due to laboratory problems or sample matrix problems. Laboratory performance is also measured by spiking with surrogate compounds prior to sample preparation.

Accuracy can be expressed as the percent recovery (%R) as determined by the following equation:

$$\%R = [(SSR-SR)/SA] \times 100$$

where: SSR = spiked sample result
SR = sample result (native)
SA = spike added

Precision is the measure of agreement or repeatability of a set of replicate results obtained from repeat determinations made under the same conditions. The precision of a duplicate determination can be expressed as the relative percent difference (RPD) as determined by the following equation:

$$RPD = [(X_1 - X_2)/(X_1 + X_2)] \times 200$$

where: X_1 = first replicate value
X_2 = second replicate value

For a given laboratory analysis, the replicate RPD values are tabulated, and the mean and standard deviation of the RPD are calculated. Control limits for precision are usually plus or minus 2 standard deviations from the mean. Laboratory precision limits for the analytical work were those presented in Table 4-8.

Accuracy and precision were monitored by using field duplicate/replicate, matrix spike, and matrix spike duplicate samples. Acceptable limits for those parameters are presented in Table 4-8. These data alone cannot be used to evaluate the accuracy and precision of individual samples, but were used to assess the long-term accuracy and precision of the analytical method.

4.4.2 Representativeness

Representativeness is the degree to which sample data accurately, and precisely, represent parameter variations at a sampling point. Otherwise stated, representativeness is a measure of how closely the measured results reflect the actual distribution and concentration of certain constituents in the medium sampled. Sample collection and handling procedures are described in the SOPs presented in Appendix . Documentation of field and laboratory procedures was used to establish that protocols had been followed and that sample identification and integrity had been maintained. These procedures helped generate samples that were as representative as possible.

4.4.3 Completeness

Completeness is defined as the percentage of analytical measurements that are judged to be valid. Percent completeness is calculated as the number of valid analyses divided by the total number of analyses performed, multiplied by 100. The completeness objective for this project was to obtain valid analytical results for a minimum of 85 percent of the samples collected.

4.4.4 Comparability

Comparability expresses the confidence with which one data set can be compared with another data set from a different sampling phase or from a different program. Comparability involves a composite of the above parameters, as well as design factors such as sampling and analytical protocols. An acceptable level of comparability can be accomplished through the consistent use of accepted analytical and sampling methods. The comparability criterion becomes important if more than one field team is collecting samples or if more than one laboratory is analyzing the samples.

4.4.5 Detection Limits

The detection limits for the analytical methods are as defined by *Test Methods for Evaluating Solid Waste SW-846*, Third Edition, December, 1986 and *Standard Methods for the Examination of Water and Wastewater*, 16th Edition, 1985.

4.4.6 Performance Evaluation Program

To ensure that environmental data collection activities resulted in the delivery of analytical data of known and documented quality that was suitable for its intended use, single and/or double blind Performance Evaluation (PE) samples, obtained from commercial vendors, were used during the project. Use of the PE samples was in general accordance with *EPA Region I Performance Evaluation Program Guidance*, dated July 1996.

The EPA Region I PE Program serves three major functions:

- To identify a community of technically capable laboratories during laboratory pre-award evaluations;
- To evaluate the performance of analytical laboratories over a period of time; and,
- To provide information on a laboratory's ability to accurately identify and quantitate analytes of interest during the period of sample preparation and analysis.

The following PE Program requirements were used during the Airport/Klondike investigation:

- One single or double blind PE sample was used for each sample matrix, analysis parameter, and concentration level for each Sample Delivery Group (SDG) that was sent to a laboratory. An SDG is defined as a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. The PE samples were counted as field samples in the SDG total 20 samples.

- PE samples were required for all analytical testing when they are available from commercial vendors in the appropriate matrix and at the proper concentration level.

Additionally, PE samples contained as many target analytes as possible, but always contained at least one of the target analytes, when possible, a contaminant of concern at the site.

For soil/sediment/solid sampling events where the only aqueous samples were equipment and/or trip blanks, an aqueous PE sample was included when a soil/sediment/solid PE sample did not exist from a commercial vendor for that analytical parameter.

4.5 Documentation

As noted above, the need to maintain accurate and complete documentation of each phase of the investigation was a paramount concern. As a result, each phase of the investigation was documented in the field and the field documentation was then reviewed to ensure all necessary data had been obtained. The following documentation procedures were performed during the investigation activities conducted at the Site.

4.5.1 Survey

A series of relative location surveys were performed during the course of the investigation activities. The intent of the initial survey was to locate each of the sample points as depicted in the VCAP Work Plan. Following the installation or the performance of sampling at a given location, a subsequent survey was performed to locate the sample point. This subsequent survey was performed to identify any adjustments in the location of the sample point required due to limitations encountered during installation.

All sample locations installed during the period from January 1996 through November 1997 were field located by an instrument survey referenced to a known horizontal and vertical datum. In addition, the groundwater monitoring wells installed during previous investigations at the Site were field located by instrument survey. In order to maintain consistency with previous site survey data, the horizontal and vertical data utilized in the Site survey activities were referenced from existing monitoring wells at the Site. All elevations have been referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). All survey information used to locate sampling points and other pertinent features on the Site were transferred to AutoCAD® drawings which served as the base maps for data presentation in this report.

4.5.2 Sample Location Identification

Samples were designated using the procedures described in the SOPs included in the VCAP Work Plan. In general, sample identification information included the following:

- Sample location (*i.e.*, North Airport, North Klondike, *etc.*);
- Sample type (*i.e.* soil boring, monitoring well, vapor probe, *etc.*); and
- Sample point number.

Monitoring wells, as well as piezometers, stream gauges, surface water and sediment sampling locations, and soil borings, have been provided with location identifiers using a systematic method to prevent duplication of location identifiers. Because of the large areas involved, the study areas that encompass the Airport/Klondike Area include the North and South Airport Areas and the North and South Klondike Areas. All monitoring and sampling locations have been given a location identifier based on their location in the Airport/Klondike Area, the type of sampling or monitoring location, and finally a sequential numeric identifier based upon the specific type of location.

The system of location identifiers provides a relatively easy means of finding the referenced locations on site maps. All parts of the P&W East Hartford facilities, including the Andrew Willgoos Gas Turbine Laboratory, the Colt Street facility, and Main Street facility, have been divided into twenty-nine study areas. Each of the study areas has been assigned two-letter identifiers based upon the common name for the area. These two-letter designations are presented in Table 4-9.

In addition, each type of sampling location has been assigned a two-letter designation to identify the major sample type for a given sampling location. The two-letter designations for the various types of sampling locations are also presented in Table 4-9.

4.5.3 Daily Field Summary Reports

During each day of field activities, a record of the events was prepared in the field. This record is referred to as a Daily Field Report and, as appropriate, would include a summary of the daily activities, a field instrumentation and quality assurance record, a field sampling record, chains-of-custody for all samples submitted for analysis, and field-prepared boring logs, well completion logs, or test-pit excavation logs.

4.5.4 Field Measurements

Field measurements collected on the Site included physical data (e.g., pH, temperature, dissolved oxygen, specific conductance, well depths, and depth to groundwater). Measurements were recorded in the field and transferred manually from the field data sheets contained in the Daily Field Report to the electronic database. The electronic database is described in greater detail in the following parts of this section. Field sampling information check sheets were printed from the database each day. These check sheets were compared against the corresponding field records and any necessary corrections were forwarded to data management personnel.

4.5.5 Geologic Information Records

Soil boring logs, test-pit excavation logs, and well completion logs are the basic forms for recording geologic information obtained during the investigation activities conducted at the Site. Soil samples from borings advanced across the Site for the purposes of the environmental setting investigation and for assessing the nature and delineating the extent of contamination were classified and logged. Soils were described in accordance with a modified Burmister soil classification system, which was presented in the appropriate SOP in the VCAP Work Plan. All hand-written boring logs were subsequently typed for ease of review.

The data presented in individual boring logs was used for various types of presentation, as appropriate. Copies of the typed soil boring logs, and well completion logs for groundwater monitoring wells installed during the course of the investigations described herein are included in Technical Memoranda (TM) 1, *Monitoring Well Installation And Development And Soil Sampling*, and TM 5 *Soil Boring Installation And Soil Sampling*. Typed test-pit excavation logs for test-pit excavations are provided in TM 10, *Test Pit Installation and Soil Sampling.*

Limited soil boring and well construction data was included in the boring information and sample information portions of the electronic database for the Site. Boring logs included such information as lithology, blow counts (if appropriate), sample collection information, and field VOC screening results. Sample collection information such as depths and photo ionization detector (PID) screening data included on the field soil boring sampling records were manually entered into the electronic database. Monitoring well information such as the screened interval and selected construction details was also entered manually.

4.5.6 Samples Submitted for Laboratory Analysis

As outlined in the SOPs included in the VCAP Work Plan, samples collected and submitted to the laboratory for analysis (either physical or chemical analysis) were appropriately labeled and logged on Chain-of-Custody forms. Copies of completed Chain-of-Custody records for samples submitted for analysis or archiving were submitted to the Project Manager at the end of each working day.

In the case of samples collected during the contaminant delineation phase of the investigation, the sampling methodology was based on an understanding of the potential contaminant release pathways for a given environmental unit, a review of materials encountered at each soil boring location, and a review of screening data from the LEA Analytical Laboratory. Because not all of this information was available at the time of sample collection, selection of samples for analysis at the off-site analytical laboratories could not be performed in the field. To accomplish the task of sample selection and to maintain the Chain-of-Custody control for all samples collected, all soil samples were submitted under proper Chain-of-Custody control to both the off-site analytical laboratories and the LEA Analytical Laboratory. All soil samples were first screened for the presence of select VOCs in the LEA Analytical Laboratory in accordance with the VCAP Work Plan. For analysis performed at the off-site analytical laboratories, a Sample Selection Form was completed by the Project Manager to identify only those samples to be analyzed. The remainder of the samples, which were not analyzed by the off-site analytical laboratories, were identified for disposal.

4.5.7 GC/VOC Screening Results

In order to screen soil samples to aid in sample selection and evaluation of contaminant distribution in areas where VOCs were suspected to be present, analysis was conducted at the LEA Analytical Laboratory for select VOCs using a portable gas chromatograph. Analytical results were reported by the laboratory in both hard-copy and electronic formats. Paper copies of laboratory reports were generated from the Laboratory Information Management System (LIMS) by the LEA Analytical Laboratory. When they were verified by the Laboratory Manager, the data were transmitted electronically to the analytical information portion of the electronic database.

The results of daily screening for target VOCs by the LEA Analytical Laboratory were maintained in an electronic database as discussed in the following parts of this section. Initial draft laboratory analysis summary sheets were submitted to the LEA Project Manager within a day of the analysis for review and use by project personnel. These draft summaries were considered when selecting samples for analysis at the off-site analytical laboratories and were filed in the project notebooks.

4.5.8 Laboratory Analytical Results

In addition to the analysis for the presence of select VOCs in soil, groundwater, and blank samples performed at the LEA Analytical Laboratory, analysis for VOCs, SVOCs, Site-specific target metals, physical characteristic parameters, and TPH were performed by the off-site analytical laboratories. The analytical results from the off-site analytical laboratories were delivered in both paper and electronic formats to the Project Manager. After documentation of receipt of the results, the electronic format was sent to the Database Manager for incorporation into the electronic database.

4.6 Data Validation

With the exception of soil and groundwater samples collected prior to approximately May 1997, all analytical data for soil and groundwater samples analyzed by the off-site analytical laboratories were subjected to validation by the LEA Analytical Laboratory staff. Data collected prior to approximately May 1997 were not validated.

The basis of the validation was the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA-540/R-94/012) and USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA-540/R-94-013). However, these guidelines were modified to incorporate method and project-specific criteria rather than Contract Laboratory Program (CLP) criteria. The following elements (if applicable by method) were reviewed for 100 percent of the soil, groundwater, and blank samples analyzed by the off-site analytical laboratories as described above:

- Holding times;
- Blanks;
- Field duplicates;
- Surrogates;
- MS/MSDs or MS/laboratory duplicates;
- Internal standards; and,
- Laboratory control samples.

The results of the validation are summarized in validation reports that include the following:

- Samples included in the validation,
- Validation guidelines used, including any project-specific modifications,
- Analyses performed,
- Review elements, and,
- Discussion of validation results, including any qualifiers appended.

Qualifiers used were from the USEPA national functional guidelines cited above. The data validator manually entered data qualifiers into the analytical information portion of the electronic database, as necessary.

4.7 Data Verification

The objective of data verification was to ensure the agreement between analytical data in hard-copy and electronic formats. Data verification entailed the comparison of the analytical data and laboratory reports received from the LEA Analytical Laboratory and the off-site analytical laboratories with the data reports generated by the electronic database. In the case of analytical reports obtained from the off-site analytical laboratories, data verification was performed in two steps, one occurring prior to validation and one occurring after data qualifiers received from the LEA Analytical Laboratory were manually entered into the analytical information portion of the electronic database.

Additionally, an initial review of all data obtained from field measurements was performed by the Project Manager. This review consisted of checking procedures utilized in the field, ensuring that field measurement instruments were properly calibrated, verifying the accuracy of transcriptions, and comparing data obtained in the field to historic measurements.

4.8 Data Management

Geologic, hydrologic, physical, and chemical data were generated during the Site investigation. Availability of this data was critical to the ongoing investigation activities. The procedures, personnel, and software used for inventory, control, storage, verification, and presentation of data were described in the VCAP Work Plan.

Procedures discussed in the VCAP Work Plan included those used for communication within the project team, focusing on the exchange of information among the field sampling team, data management team, Technical Task Leaders, Project Manager, and laboratories. The systems used to collect, store, and analyze the project data are the same as those detailed in the VCAP Work Plan.

4.9 Database Repository

The electronic project information system is a dBASE® application, which is used for electronically managing sample information and analytical data. The database management functions employed during the investigation activities at the Site are presented in the VCAP Work Plan.

4.10 Data Presentation

The objective of data presentation is to illustrate the analytical and geological/hydrogeological data for the Site in formats that facilitate data interpretation and visualization. These formats include tables, figures, and drawings, as appropriate.

4.10.1 Analytical Data Presentation

Two types of analytical data presentation were generated from the electronic database: *final tables* generated in a format designed for inclusion in the final report, and *working tables* generated for specific uses by the Technical Task Leaders, Project Manager, and other project personnel during the course of the investigation.

Types of information generated into tabular formats and included in this report include:

- Listings of location and sample collection information;
- Listing of constituents for which a sample was analyzed;
- Site information, including measurements of groundwater elevation and sample/station location coordinates; and
- Analytical data, including constituents of concern, analyte concentrations, and qualifiers.

The analytical data tables are presented as summaries of detected constituents, with separate tables generated to indicate constituents for which a sample had been analyzed. These tables are presented in Section 6 of this report.

4.10.2 Facility Maps

Facility maps were created using AutoCAD® software. The project base maps were generated using available information from a variety of sources that has been incorporated into the AutoCAD® files.

Examples of facility maps generated for this report include:

- Site Plan;
- Locations of environmental units; and
- Soil vapor, soil, and groundwater sampling, and test-pit excavation locations.

4.10.3 Graphical Data Display

Graphical data display combined analytical data and/or geological/hydrogeological data with information from the facility base map.

Examples of graphical outputs include:

- Groundwater and potentiometric surface contours maps;
- Areal distribution of contaminant concentrations in soil or groundwater;
- Generalized bedrock surface contour maps; and
- Cross-sections of stratigraphy.

4.11 Record-keeping Procedures

4.11.1.1 Office Documentation

All documentation related to project activities, including field activities, will be maintained by the project manager until completion of the project. Records will be maintained in a project notebook or other suitable format to ensure their organization and accessibility.

4.11.1.2 Field Documentation

Records that will be maintained as documentation of field activities include field logbooks, daily field report forms, field quality review checklists, field instrumentation and quality assurance records, field sampling records, data collection records from groundwater monitoring and sampling, well development reports, soil gas survey data records, boring and test pit logs, and chains-of-custody for collected samples. All appropriate documentation will be completed in the field and returned to the office for inclusion in the project file. At a minimum, field logbooks, daily field report forms, and field quality review checklists must be completed for each day of field activity.

4.11.2 Archiving

Following completion of the project, all records associated with that project (including reports, project notebooks, field records and logbooks, and laboratory reports and chains-of-custody) were archived in a manner that permits their retrieval in an efficient manner should reference to the documents be required in the future.